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Impacts of *Euhrychiopsis lecontei* (Dietz) from Different Populations on the Growth and Nutrition of Eurasian Watermilfoil

by Alfred F. Cofrancesco, Dwilette G. McFarland, John D. Madsen, Angela G. Poovey, Harvey L. Jones

PURPOSE: This technical note provides information on the potential effects of the native weevil *Euhrychiopsis lecontei* on growth of Eurasian watermilfoil. Weevil impacts are identified based on evaluations of plant biomass, shoot height, and plant tissue nutrient characteristics. Populations of weevils from different geographical locations were tested and all proved to be of potential value to Corps biocontrol efforts.

BACKGROUND: Eurasian watermilfoil (*Myriophyllum spicatum* L.) is an exotic, submersed aquatic plant, considered one of the most aggressive and troublesome species in North America (Figure 1). Current evidence suggests it to be native to Europe, Asia, and northern Africa; it was introduced in the United States near Washington, DC in the early 1940s (Couch and Nelson 1985). Since that time, it has spread throughout much of United States (Figure 2) and now occurs in southern provinces of Canada, in British Columbia, Quebec, and Ontario (Sheldon and Creed 1995, Jacono and Richerson 2003, Washington State Department of Ecology 2003).

The success of Eurasian watermilfoil in a wide range of aquatic systems is attributable mainly to two important plant characteristics: the plant's ability to photosynthesize at low temperatures, allowing it to grow rapidly to the surface in spring and increasing its ability to compete with other plant species at high latitudes (Barko and Smart 1981; Barko et al. 1982); and its propensity for generating a large number of propagules (fragments) that disperse to other areas to establish new colonies (Kimbel 1982; Nichols and Shaw 1986; Madsen et al. 1988). Stem fragments may result from mechanical breakage (allofragments) or through natural processes associated with plant senescence (autofragments). Stolons or underground runners provide additional means of expanding the plant bed as well as serving as primary structures for perennation (Madsen et al. 1988). Although the role of seeds in the dispersal of this species has not been rigorously studied, its seeds have shown high viability in the laboratory but are seldom observed growing in nature (Aiken et al. 1979; Madsen and Boylen 1988, 1989; McFarland and Rogers 1998).

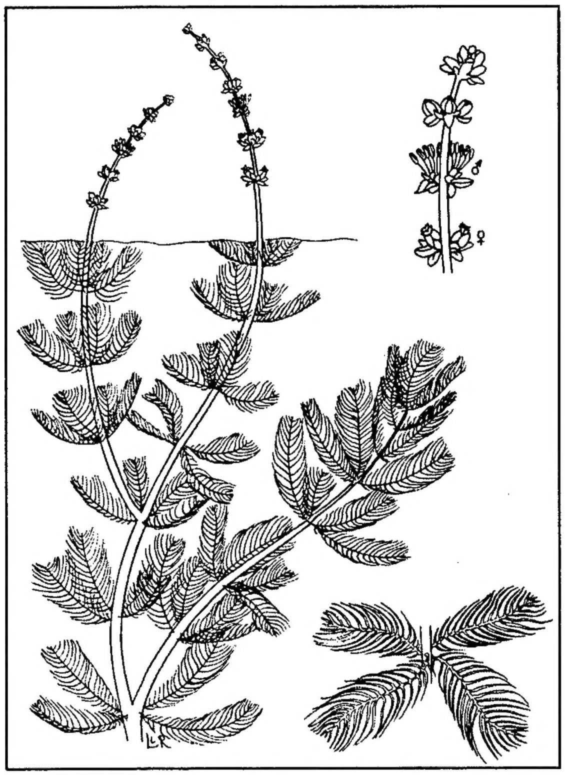

Figure 1. Eurasian watermilfoil (*Myriophyllum spicatum* L.). Illustration provided by IFAS, Center for Aquatic Plants, University of Florida, Gainesville; 1990

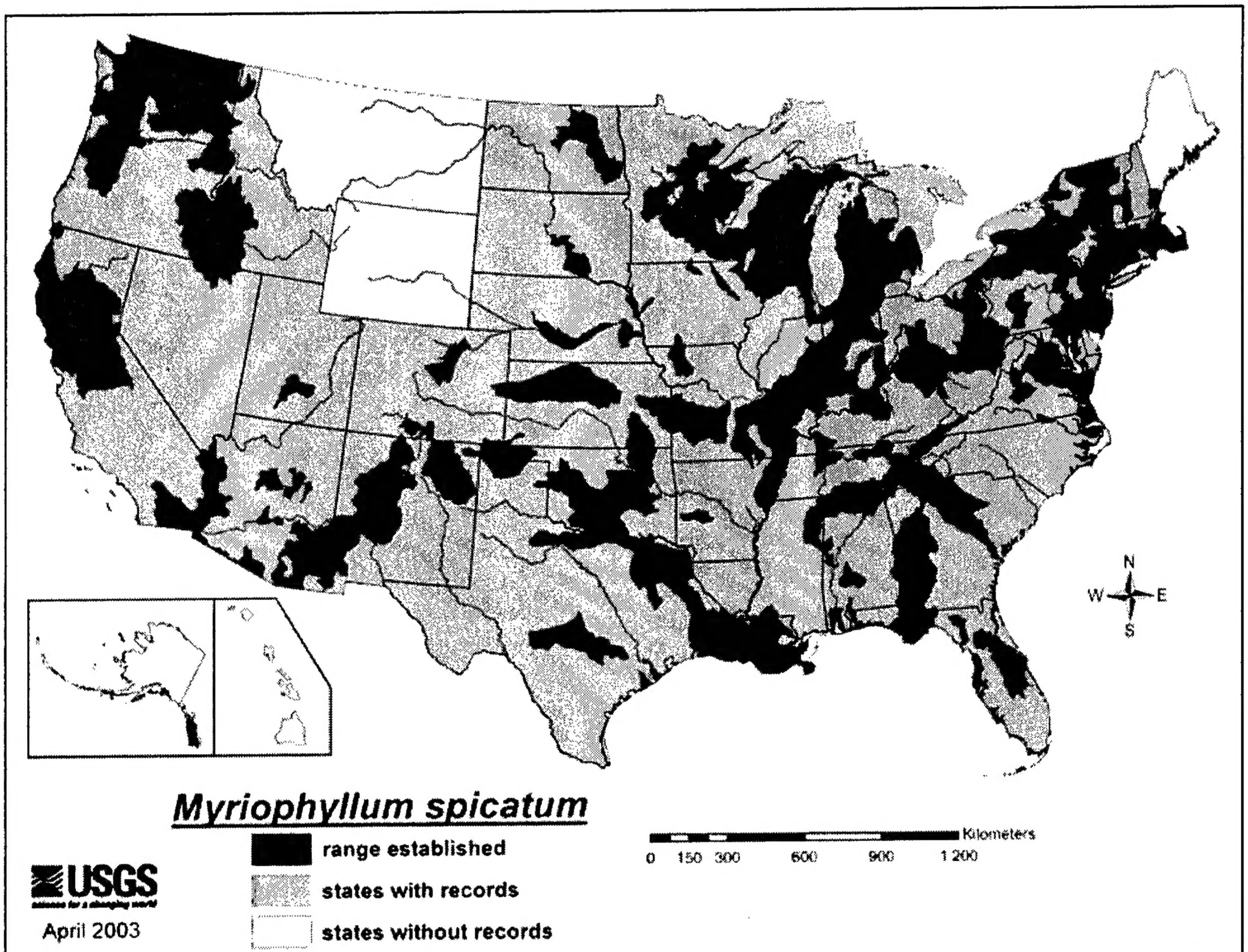

Figure 2. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in the United States. Map according to Jacono and Richerson 2003.

The growth habit of Eurasian watermilfoil is particularly problematic because of the large amounts of biomass that the plant produces at the water surface. Its dense canopy of entangled stems can restrict light penetration, enabling it to shade out more conservative, "understory" aquatic vegetation. Fragments and floating mats of this species hinder recreational water use and navigation and have been reported to clog water intake structures at power generation and water treatment facilities (Smith et al. 1967; Grace and Tilly 1976). Additionally, the decay of large amounts of biomass associated with Eurasian watermilfoil infestations can markedly alter water quality to the detriment of other biota (Grace and Wetzel 1978).

Traditional methods to control Eurasian watermilfoil have had only short-term success, at best, and often involve expensive management operations. In many states, including Washington, Vermont, Minnesota, and New York, private and government sources spend hundreds of thousands of dollars each year to control Eurasian watermilfoil (Washington State Department of Ecology 2003). Thus far, the most commonly used control methods have included chemical herbicide treatments, mechanical harvesting, and habitat manipulations through adjustments in water levels. However, the potential for biological control (biocontrol) has prompted considerable interest in research to find an ecologically compatible, long-term solution.

The U.S. Department of Agriculture and Army Corps of Engineers have been working jointly in the search for effective biocontrol agents for Eurasian watermilfoil. Current efforts are focused mostly on the weevil *Euhrychiopsis lecontei* Dietz (Figure 3), which has shown the greatest promise regarding its feeding specificity and ability to be cultured in the laboratory (Solarz and Newman 1996). This weevil is a native of North America and appears to prefer Eurasian watermilfoil to its native host *M. sibiricum* Komarov (northern watermilfoil). Damage to the plant results from larval tunneling into the stem, causing stress presumably by restricting translocation of gases and nutrients. The complete life cycle takes from approximately 17 to 30 days at summer temperatures averaging between 20 and 27°C (Newman et al. 1997; Mazzei et al. 1999).

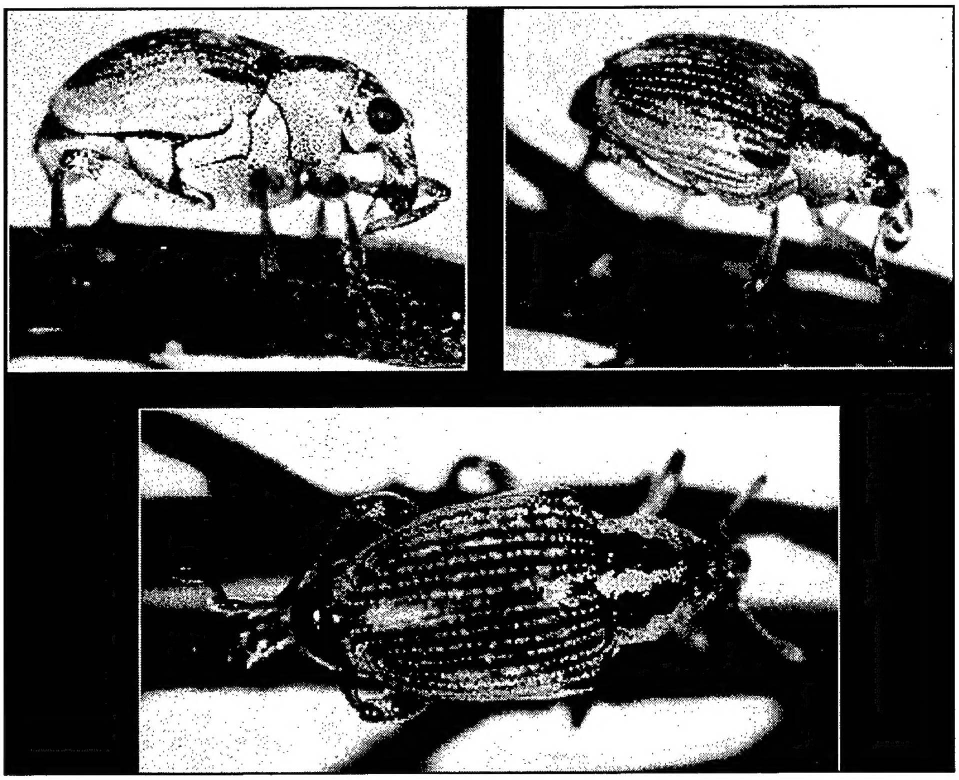

Figure 3. *Euhrychiopsis lecontei* (Dietz), a native weevil of North America. Photo from the Aquatic Plant Information System, US Army Corps of Engineers, 1998.

As a preliminary step towards the biocontrol of Eurasian watermilfoil, it is necessary to identify sources of agents likely to be most effective. Marked variations in plant damage by *E. lecontei* in the field suggest possible differences in vigor or some other property (e.g., density and/or demography) among populations of the weevil. In the investigation conducted recently at the U.S. Army Engineer Research and Development Center (ERDC), researchers examined effects of different weevil populations on growth of Eurasian watermilfoil. Results presented here describe physical and nutritional changes in the plants due to exposure to *E. lecontei* obtained from three separate locations in the United States.

METHODS AND MATERIALS: The investigation was conducted July-September 1998 in an environmental growth chamber at the ERDC, in Vicksburg, Mississippi. This facility was operated

to maintain 25°C and simulated sunlight at 350 μE m^{-2} s^{-1} for 14 hrs d^{-1}. Aquaria for Eurasian watermilfoil consisted of clear, lucite columns (150 cm tall, 20-L volume) with 3.5-L removable bases (Figure 4). Detailed descriptions of the environmental chamber, ancillary equipment, and column assemblage are provided by Barko and Smart (1980).

The sediment used in the study was a fine-textured medium (< 10 percent coarse particles) collected locally from Brown's Lake, on station at the ERDC. The sediment was amended with sufficient NH_4Cl (added as 0.7g L^{-1} wet sediment) to ensure favorable nutrient conditions over the 8-week study period. After mixing, the sediment was poured 25 cm deep in the column bases, each with a surface area of approximately 90 cm^2. Physical and chemical characteristics of the sediment after nutrient amendment were similar to those described by McFarland and Barko (1999).

Four sprigs of Eurasian watermilfoil, clipped 20 cm in length, were planted in each sediment container, with basal ends buried 5 cm in the sediment. Once planted, the sediment was covered with a thin layer of sand, the columns were assembled, and the plants submersed in 15 L of culture

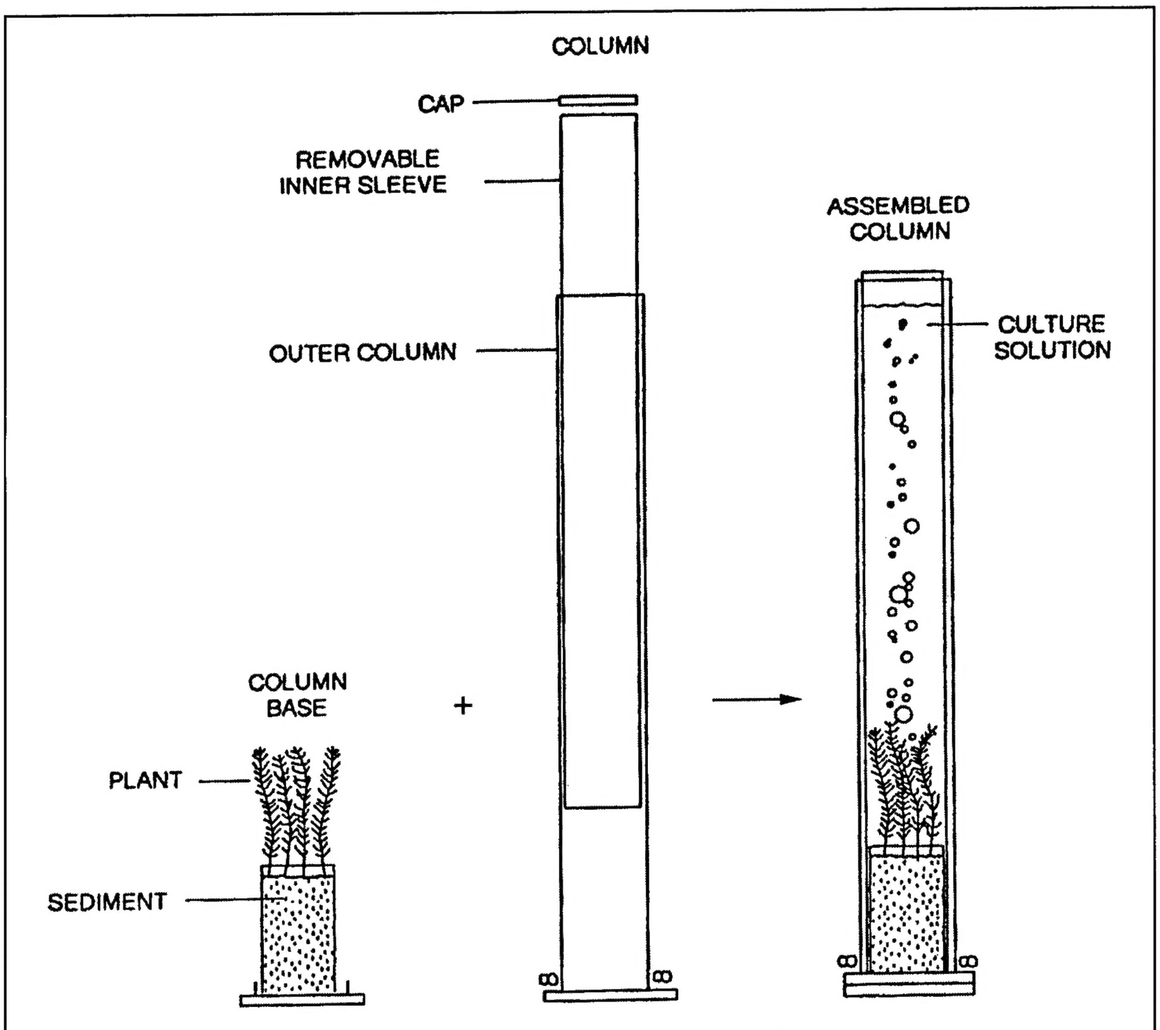

Figure 4. Column assembly

solution. The solution was prepared using reagent-grade salts and deionized/distilled water according to procedures for the low-alkalinity solution by Smart and Barko (1985).

Twenty columns of Eurasian watermilfoil were divided equally into five groups, each consisting of four replicates. Plants in each group were allowed to grow for 4 weeks, after which one group, the 'pre-treatment control group,' was harvested. Of the four remaining groups, three were treated separately with six mated pairs of *E. lecontei*. The weevils had been obtained previously from three different locations, including: Vermont (V), Minnesota (M), and a private company (C). One group was left untreated as the 'post-treatment control group' and was harvested, along with the three treatment groups (V, M, and C) after an additional 4 weeks of growth. Plant growth and nutritional status were assessed at each harvest and were based on evaluations of plant biomass, shoot length, and nutrient (total nitrogen and total phosphorus) concentrations in the plant tissues.

STUDY FINDINGS: Plants exposed to the weevils showed marked reductions in shoot length, with treated plants showing a 33.8- to 45.3-percent reduction compared to the post-treatment control plants (Figure 5). Interestingly, the measured biomass responses showed little if any weevil effects, although aboveground stems (especially the upper portions) were visibly severed and damaged internally by larval tunneling. These results suggest that while the weevils did not consume large amounts of plant biomass, their feeding caused a significant decline in viable standing stems. Shoot

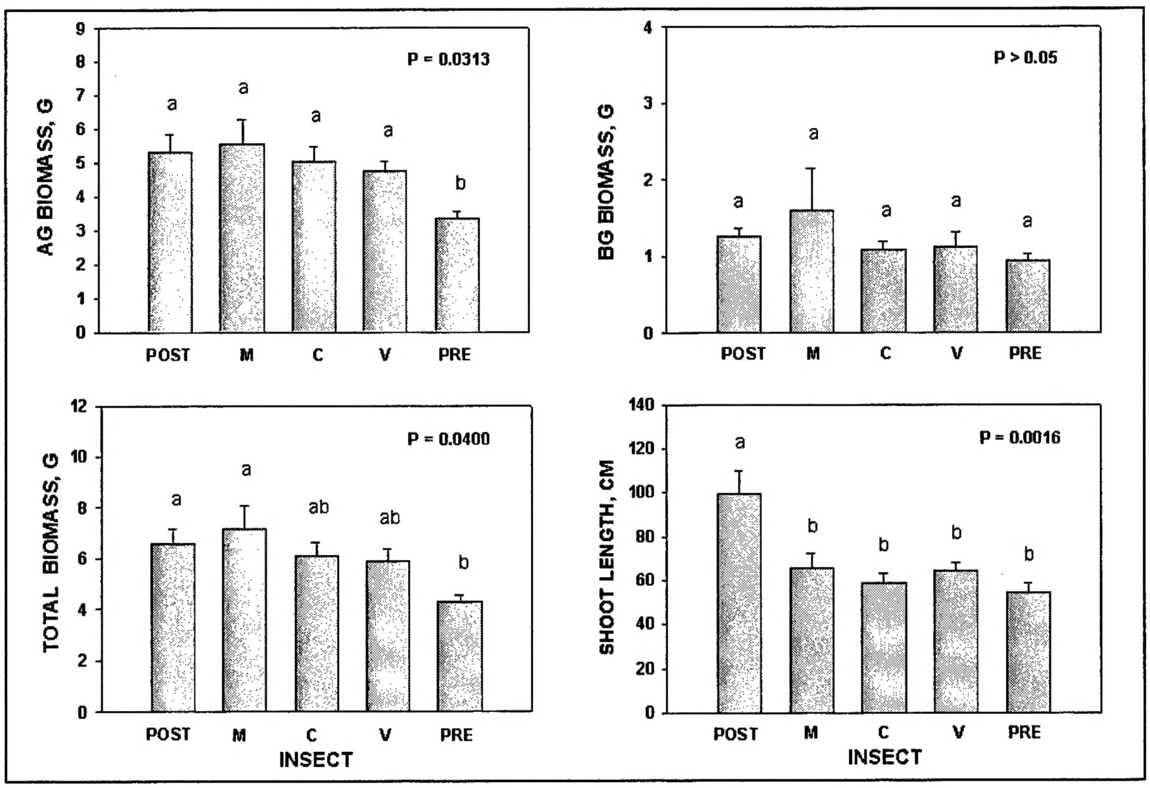

Figure 5. Effects of *Euhrychiopsis lecontei* from three different sources (M = Minnesota, C = commercial company, V = Vermont) on biomass (AG = aboveground, BG = belowground) and shoot length of Eurasian watermilfoil. Each bar represents the mean ± 1 standard error (n = 4) for weevil-treated groups and non-treated control groups (PRE = Pretreatment control group; POST = Post-treatment control group). Bars sharing the same letter do not differ significantly at $P < 0.05$.

length was also determined to be the most affected plant variable in a previous pilot study of impacts of *E. lecontei* on Eurasian watermilfoil (Cofrancesco 1998, unpubl. data).

Evaluations of the nutritional status of the plants indicated similarly high concentrations of nitrogen (N) in tissues of pre- and post-treatment control groups (Figure 6). In contrast, weevil-treated plants showed a significant dilution in tissue N, averaging 25 to 28 mg/g compared to 35 mg/g in the controls. Tissue phosphorus (P) concentrations were less affected than those of tissue N and varied to a relatively minor extent among weevil treatments (Figure 6). The greatest reduction in tissue P occurred in V-treated plants with concentrations diminished by approximately 20 percent.

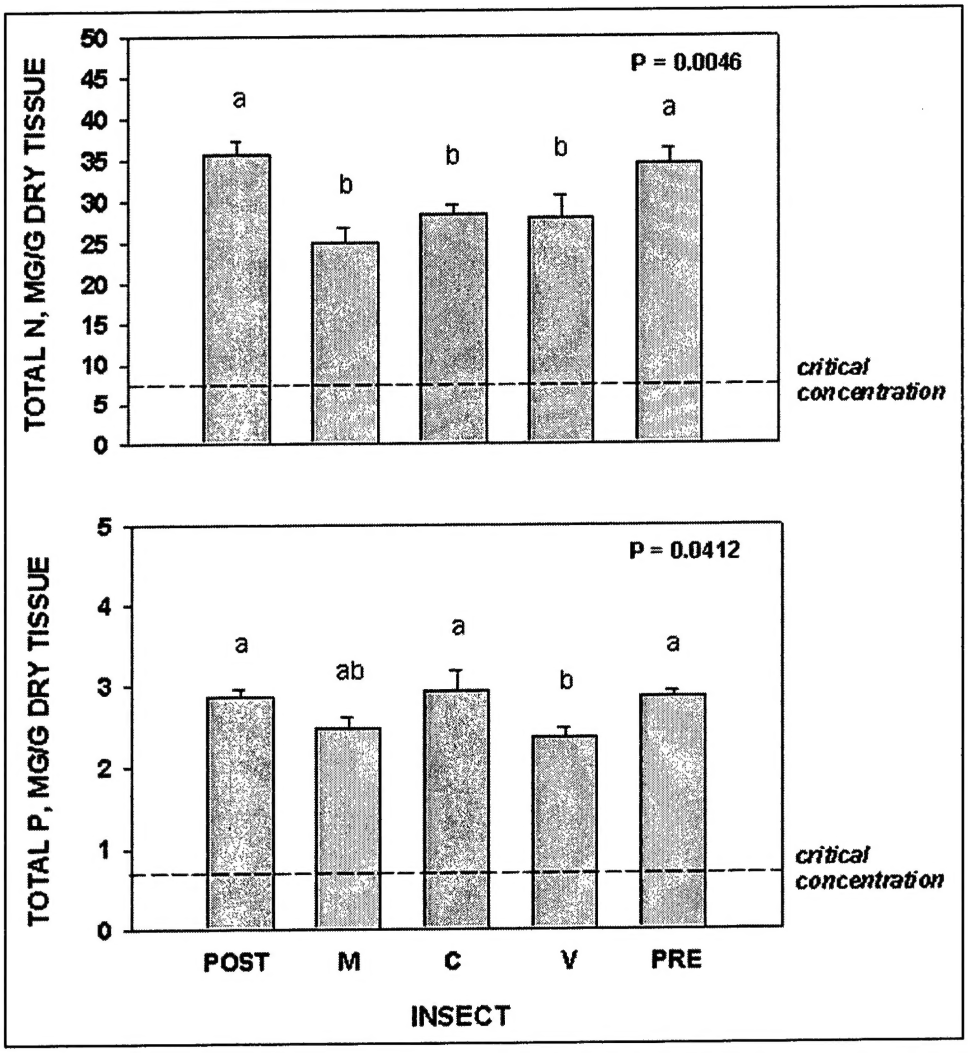

Figure 6. Effects of *Euhrychiopsis lecontei* from three different sources (M = Minnesota, C = commercial company, V = Vermont) on nitrogen and phosphorus concentrations in shoot tissues of Eurasian watermilfoil. Each bar represents the mean ± 1 standard error (n = 4) for weevil-treated groups and non-treated control groups (PRE = Pretreatment control group; POST = Post-treatment control group). Bars sharing the same letter do not differ significantly at $P < 0.05$.

CONCLUSIONS AND RECOMMENDATIONS: This study provides evidence that the herbivory of *E. lecontei* can impose considerable damage to growth of Eurasian watermilfoil. These findings generally support the results of previous research showing that feeding by *E. lecontei* on Eurasian watermilfoil diminishes the plant's health and ability to elongate (Creed et al. 1992; Creed and Sheldon 1993; Newman et al. 1996). Here, reductions in plant height due to the weevils boring into and severing the plant stems were coupled with nutritional stresses imposed by restricting the concentration of nutrients (especially N) in plant tissues. Because the amount of biomass of the treated plants was essentially unchanged by weevil feeding, it appears that damage to the plant was controlled more by tunneling than by measurable consumption of plant biomass.

The results of this study raise further questions concerning whether the weevils can cause plant death and if so, at what weevil densities and plant physiological status? In the present study, weevil impacts were assessed using laboratory-cultured plants with tissue N and P concentrations well above critical values (Figure 6) (Gerloff 1975; Barko and Smart 1986). However, further studies are needed to determine how plant tissue nutrient concentrations may affect *E. lecontei* herbivory and population dynamics.

Overall, the three weevil populations tested in this study were rather similar in their ability to hinder the growth of Eurasian watermilfoil. Yet, before conclusions can be drawn concerning their relative capabilities, these populations should be tested on multiple occasions and for different periods over the growing season. The effectiveness of weevils from different geographical locations is likely to vary due to environmental factors that effect unique behaviors, and morphological and physiological characteristics. Such distinctions could become more apparent with additional testing in the laboratory and could be used as a basis for biocontrol agent source selection. Knowledge of the strengths and weaknesses of different weevil populations would be useful in identifying those best suited for certain field conditions.

POINTS OF CONTACT: For additional information, contact Dr. Alfred Cofrancesco, (601) 634-3182, *Al.F.Cofrancesco@erdc.usace.army.mil*, or the manager of the Aquatic Plant Control Research Program, Mr. Robert C. Gunkel, Jr., (601) 634-3722, *Robert.C.Gunkel@erdc.usace.army.mil*. This technical note should be cited as follows:

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